



The Hexahelix Model in Regional Innovation: Evidence from Districts and Cities in Aceh Province

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<p>Received: February 09, 2026 Revised: September 27, 2026 Accepted: October 12, 2026 Available online: October 29, 2026</p>	<p>Regional innovation in Indonesia is increasingly expected to emerge from collaboration beyond government, yet it remains unclear which actors take part in local innovation and why multi-actor collaboration remains incomplete. Using the Hexahelix framework—government, academia, business, community, and media as collaborating actors, with information technology as an enabling dimension—this study examines patterns of actor participation in regional innovation and the institutional conditions that shape them. A qualitative comparative case study was conducted in seven districts/cities of Aceh Province representing the three categories of the 2023 Regional Innovation Index: less innovative, innovative, and very innovative. Data were drawn from semi-structured interviews with 14 officials of district/city and provincial regional development planning agencies (Bappeda), which recorded the involvement of each Hexahelix element in 125 regional innovations, and from policy documents; the data were summarised using descriptive frequencies, analysed interactively, and compared across cases. At least 35 innovations (28.0%) involved a non-government Hexahelix actor, ranging from 17.0% in Aceh Jaya, the only very innovative case, to 88.9% in Banda Aceh City, and none met the complete Hexahelix configuration. Media (28.0%) and community (19.2%) were involved more often than academia (16.0%), while business took part in only 6.4% of innovations; 47 innovations (37.6%) were application-based. The Index category therefore reflected the volume of innovation more than the depth of collaboration. Full Hexahelix collaboration was constrained by uneven local policy support, limited budgets, insufficient guidance for innovation initiators, and the confinement of innovation within individual government agencies. This study contributes by employing the Hexahelix model as an analytical lens for identifying missing collaborative linkages, especially with business, rather than as a normative prescription.</p>
KEYWORDS	
<p>Hexahelix Model; Regional Innovation; Collaborative Governance; Multi-Actor Collaboration; Regional Innovation Index.</p>	
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INTRODUCTION

Regional development continues to change in line with advances in science and technology. The era of globalization continues to experience rapid progress in various aspects of life. This also impacts progress in improving public services for the advancement of a region. Services at the provincial and district/city levels currently vary greatly in the context of public service strategies. The goals of disseminating information and maximizing services to the community, government agencies, and the private sector continue to evolve. Regencies/cities are at the forefront of realizing public services by utilizing human resources and regional potential to realize optimal public services and increase regional competitiveness. All of this aims to meet community needs in a sustainable manner in accordance with current developments. According to Rogers, one of the leading authors of innovation books, innovation is an idea, practice, or object that is perceived as new by individuals from one unit of adoption to another (Rogers: 2003).

Since the enactment of Law No. 23/2014 on Regional Government, innovation has become a formal mandate of Indonesian local governments. Article 386 authorises regional governments to innovate in order to improve the performance of regional governance, and Government Regulation No. 38/2017 classifies regional innovation into governance innovation, public service innovation, and other innovations within regional authority. The Ministry of Home Affairs operationalises this mandate through the annual Regional Innovation Index (IID), which classifies provinces, districts, and cities as very innovative, innovative, or less innovative and links their performance to fiscal incentives from the central government (Ministry of Home

Affairs, 2023). Within this regime, collaboration is not optional: the assessment rewards innovations that engage partners beyond the initiating agency, implicitly assuming that local governments can mobilise universities, firms, communities, and media around their innovation agendas. Whether, and under what conditions, such multi-actor collaboration actually materialises at the local level remains an open empirical question.

This question sits at the centre of a broader shift in the study of public sector innovation. Systematic reviews show that public sector innovation is shaped less by individual agencies than by the environmental, organisational, and inter-organisational conditions in which it takes place (De Vries et al., 2016). Scholars of collaborative innovation argue that public problems are increasingly addressed through the interaction of public and private actors who bring different resources, knowledge, and perspectives to the innovation process (Sørensen & Torfing, 2011; Torfing, 2019). The collaborative governance literature further specifies that such interaction depends on starting conditions, institutional design, facilitative leadership, and the dynamics of principled engagement, shared motivation, and capacity for joint action (Ansell & Gash, 2008; Emerson et al., 2012). From an innovation ecosystem perspective, performance depends not only on the presence of actors but also on the relations and complementarities among them (Granstrand & Holgersson, 2020). Taken together, these strands suggest that the key analytical issue is not whether collaboration is desirable, but which collaborative linkages form, which do not, and why.

Helix models provide the most widely used vocabulary for describing these linkages. The Triple Helix model conceptualised innovation as the outcome of interactions among universities,

industry, and government (Etzkowitz & Leydesdorff, 2000). The Quadruple Helix added the media-based and culture-based public, recognising that innovation is co-produced by civil society and shaped by public communication (Carayannis & Campbell, 2009). The Quintuple Helix subsequently incorporated the natural environment of society as a further subsystem (Carayannis et al., 2012). Two features of this evolution are important for the present study. First, each new helix was justified by the analytical function it adds rather than by the number of stakeholders it includes. Second, not every helix is an actor: the Quintuple Helix treats the natural environment as a contextual subsystem rather than as a stakeholder. In Indonesia, the Pentahelix variant—government, academia, business, community, and media—has become the dominant framework for collaborative development, and a recent review calls for its extension to incorporate digital technologies (Supriyanti et al., 2026).

The Hexahelix model has emerged from this Indonesian discussion as a further extension, but its conceptual basis remains thin. Existing studies add a sixth element to the Pentahelix without agreeing on what that element is: some include non-governmental organisations (Afrijal et al., 2026), whereas others combine non-governmental organisations with affected communities (Tuthaes et al., 2024). Most applications concern tourism, the creative economy, or sectoral programmes rather than the innovation governance of regional governments, and they typically present Hexahelix as a model to be adopted rather than as a framework for analysing collaboration as it actually occurs. This additive and normative use leaves a basic question unanswered: what does a sixth element explain that five do not? Moreover, helix models implicitly assume that the relevant actors are present and able to interact. Research on sparse regional environments shows that this assumption often fails outside core regions, where firms, intermediaries, and networks are thin and collaboration has to be actively built (Salomaa et al., 2020). In such settings, the more informative question is not how many actors a model lists, but which linkages are missing and which institutional conditions prevent them from forming.

Studies of regional innovation in Indonesia have so far examined collaboration in a fragmented way. Wismono et al. (2019) recommended cross-unit collaboration to strengthen the Regional Innovation System (SIDa) in Samarinda, while Saksono (2020) proposed the Innovation Hub as a collaborative medium for building innovative regional governments. Laurens (2024) showed that Pentahelix collaboration can improve the quality of public services and regional competitiveness, and Febrian (2018) examined the regulatory basis of regional innovation under Article 386 of Law No. 23/2014. These studies confirm the importance of collaboration, but each focuses on a single mechanism—an innovation system, a hub, a regulation, or a particular helix configuration. None systematically maps which actors participate across a regional government's portfolio of innovations, and none compares collaboration patterns across regions with different levels of innovation performance. As a result, it is known that collaboration matters, but not where and why it breaks down.

This study addresses this gap by using the Hexahelix model as an analytical lens rather than as a normative prescription. It examines regional innovation in seven districts/cities of Aceh Province, selected to represent the three categories of the 2023 Regional Innovation Index—a province where the participation

of business and civil-society actors in government innovation has received little scholarly attention. Two questions guide the analysis: (1) What patterns of Hexahelix actor participation characterise regional innovation across these districts/cities? (2) Why does full Hexahelix collaboration fail to emerge, and which institutional conditions enable or constrain collaboration? By answering these questions through a qualitative comparative case study, the article makes three contributions: it offers a clearer conceptualisation of Hexahelix that distinguishes collaborating actors from an enabling dimension; it provides comparative evidence on collaboration patterns in regional government innovation; and it explains incomplete collaboration in ways that can inform the governance of regional innovation.

Building on the helix tradition, in which a helix denotes an institutional sphere rather than necessarily an actor (Carayannis et al., 2012), this study defines Hexahelix as a framework comprising five collaborating actors and one enabling dimension. The five actors are government, academia, business, community, and media. Government—here, the regional government and its regional apparatus organisations (OPD), coordinated by the regional development planning agency (Bappeda)—initiates, regulates, funds, and evaluates regional innovation (Etzkowitz & Leydesdorff, 2000; Sørensen & Torfing, 2011). Academia contributes knowledge, research, and evaluation capacity (Etzkowitz & Leydesdorff, 2000). Business contributes resources, market knowledge, and implementation capacity, including through corporate social responsibility programmes (Etzkowitz & Leydesdorff, 2000). Community—citizens, community groups, and civil-society organisations—contributes local knowledge, co-production, and legitimacy, in line with the civil-society helix of the Quadruple Helix model (Carayannis & Campbell, 2009). Media disseminates information about innovations, promotes them, and enables public scrutiny (Carayannis & Campbell, 2009). Information technology is treated not as a sixth actor but as an enabling dimension. Following the Quintuple Helix precedent of incorporating non-actor subsystems (Carayannis et al., 2012) and recent calls to integrate digital technologies into helix models (Supriyanti et al., 2026), it captures the digital infrastructure through which actors interact and through which many regional innovations are delivered. Relative to the Triple and Quadruple Helix, this framework treats community and media as distinct actors; relative to the Pentahelix, it adds an enabling dimension rather than a further stakeholder.

This conceptualisation responds to the definitional inconsistency in the existing Hexahelix literature and avoids treating a technology as a stakeholder. It also yields explicit criteria for the empirical analysis. An innovation is coded as involving a non-government actor when its records document that actor's participation in the design, implementation, funding, evaluation, or dissemination of the innovation, and as application-based when it is delivered through a digital application or platform. Collaboration is defined as the involvement of at least one non-government actor, and the complete Hexahelix configuration as the involvement of all five actors supported by information technology. These criteria allow the study to move beyond counting stakeholders and to identify which collaborative linkages are present, which are absent, and how their absence can be explained.

METHOD

This study employed a qualitative comparative multiple-case study design (Yin, 2018). The design was chosen because the research questions ask how and why Hexahelix collaboration forms or fails to form, which requires an in-depth understanding of each case and systematic comparison across cases. Numerical data are used only for descriptive quantification: frequencies and percentages derived from documentary records describe the extent of collaboration and support the qualitative interpretation, without statistical inference.

The cases are seven districts/cities in Aceh Province, selected purposively to represent the three categories of the 2023 Regional Innovation Index set by the Ministry of Home Affairs (Ministry of Home Affairs, 2023): less innovative (Nagan Raya and South Aceh), innovative (West Aceh, Southwest Aceh, Subulussalam City, and Banda Aceh City), and very innovative (Aceh Jaya). This selection allows collaboration patterns to be compared across regions with different levels of innovation performance. Officials of the Aceh Provincial Bappeda, located in Banda Aceh, were included as supporting informants because of the agency's role in coordinating regional innovation at the provincial level; the province itself is not treated as a case. Two units of analysis are distinguished. The primary unit is the innovation governance of each district/city government. The embedded unit is the individual regional innovation ($n = 125$), registered by the seven districts/cities in the 2023 Regional Innovation Index. Informants are sources of data, not units of analysis.

Data were drawn from three sources. First, documentary records of the 125 innovations were obtained from the innovation profiles submitted by each district/city for the Regional Innovation Index assessment. Each profile describes the background of the innovation, supporting data, the flow of activities, evidence of implementation, and budget support, and therefore records which parties were involved. Second, semi-structured interviews were conducted in July 2024 with 14 informants selected purposively: two officials from the Bappeda of each of six districts/cities (West Aceh, Southwest Aceh, South Aceh, Nagan Raya, Aceh Jaya, and Subulussalam City), including the heads of their research and development divisions as the officials responsible for coordinating regional innovation, and two officials of the Aceh Provincial Bappeda in Banda Aceh. As no city-level officials were interviewed in Banda Aceh, data on Banda Aceh City were drawn mainly from its innovation records and policy documents. The interviews covered the involvement of each Hexahelix actor, the coordination of innovation, regulatory and budgetary support, and the constraints on collaboration. Third, policy documents were analysed, including the Regional Medium-Term Development Plans (RPJMD), regional regulations and decrees on regional innovation, innovation reports, and Innovative Government Award (IGA) evaluation documents.

The involvement of each Hexahelix element was operationalised using the indicators in Table 1. Each of the 125 innovation records was reviewed and coded for the presence or absence of each element based on documented evidence. An innovation was classified as collaborative when at least one non-government actor was involved, and as meeting the complete Hexahelix configuration when all five actors were involved, and the innovation was supported by information technology. The coded results were summarised as frequencies and percentages for each district/city (Table 2). Interview transcripts and policy documents were coded thematically, using initial codes derived

from the Hexahelix framework (the roles of each actor) and from the collaborative governance literature (regulatory support, resources, institutional capacity, and coordination), complemented by codes emerging from the data.

Data were analysed using the interactive model of Miles et al. (2014), which comprises data condensation, data display, and conclusion drawing and verification. Within each case, the coded innovation data, interview accounts, and documents were condensed and displayed in case matrices showing which actors were involved and under what conditions. The cases were then compared across the three Regional Innovation Index categories to identify similarities and differences in collaboration patterns and in the institutional conditions that enabled or constrained them. Credibility was strengthened through source triangulation: the frequencies derived from the innovation records were checked against interview accounts and policy documents and claims about the involvement of each actor were retained only when supported by more than one source.

Table 1. Hexahelix framework: helices, functions, and empirical indicators

Helix	Type	Function in regional innovation	Empirical indicator of involvement
Government	Actor	Initiates, regulates, funds, and evaluates innovation	Innovation initiated by an OPD; regional regulation, decree on the innovation team, or budget allocation
Academia	Actor	Provides knowledge, research, and evaluation capacity	Cooperation agreement with a university or research institution; academics on assessment or evaluation teams; joint research (e.g., with BRIN)
Business	Actor	Provides resources and implementation capacity	CSR funding or in-kind support; private partner in delivery; partnership agreement (MoU/MoA) with a firm
Community	Actor	Co-produces innovation and provides local knowledge and legitimacy	Community group or civil-society organisation acting as initiator, co-implementer, or formally involved user group
Media	Actor	Disseminates, promotes, and scrutinises innovation	Documented publication or promotion of the innovation by mass or online media
Information technology	Enabling dimension	Provides the digital infrastructure for interaction and service delivery	Innovation delivered through an application, website, or digital platform

RESULTS AND DISCUSSION

Regional Variation in Innovation Performance

The seven districts/cities reported 125 regional innovations, distributed very unevenly across cases (Table 2). Aceh Jaya, the only district classified as very innovative in the 2023 Regional Innovation Index, accounted for 53 innovations (42.4% of the

total), followed by Subulussalam City (22) and West Aceh (18), while the remaining four cases each reported between seven and nine innovations. At first sight, the Index categories therefore mirror the volume of innovation: the more innovations a government registers, the higher its category.

The picture changes when the depth of collaboration is considered. Because government was involved in every innovation, collaboration is indicated by the participation of non-government actors. Two simple measures can be derived from Table 2: the minimum number of collaborative innovations in each case, given by the highest count among the four non-government actors, and linkage density, the average number of non-government actor involvements per innovation. On both measures, the most innovative case was the least collaborative. In Aceh Jaya, at least 9 of 53 innovations (17.0%) involved a non-government actor, and linkage density was 0.34, less than half the average across all cases (0.70). In Banda Aceh City, by contrast, at

least 8 of 9 innovations (88.9%) involved a non-government actor, and linkage density reached 2.22. Grouped by Index category, linkage density was 0.79 in the less innovative cases, 1.00 in the innovative cases, and only 0.34 in the very innovative case.

This divergence suggests that the Regional Innovation Index captures the quantity and administrative completeness of innovation more than the depth of collaboration behind it. Where governments pursue a higher category by encouraging all agencies to register innovations the result can be a large portfolio of innovations initiated and implemented within single agencies. A high Index category, in other words, does not necessarily indicate a dense collaborative ecosystem, whereas a smaller portfolio, as in Banda Aceh City, can be considerably more collaborative.

Patterns of Hexahelix Participation

Table 2. Distribution of Hexahelix involvement in regional innovations, by district/city

District/City	IID 2023 category	n	Government	Academia	Business	Community	Media	IT	Linkage density
West Aceh	Innovative	18	18 (100)	3 (16.7)	2 (11.1)	5 (27.8)	5 (27.8)	7 (38.9)	0.83
Southwest Aceh	Innovative	9	9 (100)	2 (22.2)	1 (11.1)	2 (22.2)	3 (33.3)	4 (44.4)	0.89
South Aceh	Less innovative	7	7 (100)	1 (14.3)	0 (0.0)	2 (28.6)	2 (28.6)	2 (28.6)	0.71
Subulussalam City	Innovative	22	22 (100)	3 (13.6)	2 (9.1)	4 (18.2)	6 (27.3)	8 (36.4)	0.68
Nagan Raya	Less innovative	7	7 (100)	1 (14.3)	1 (14.3)	2 (28.6)	2 (28.6)	2 (28.6)	0.86
Aceh Jaya	Very innovative	53	53 (100)	5 (9.4)	0 (0.0)	4 (7.5)	9 (17.0)	15 (28.3)	0.34
Banda Aceh City	Innovative	9	9 (100)	5 (55.6)	2 (22.2)	5 (55.6)	8 (88.9)	9 (100)	2.22
Total		125	125 (100)	20 (16.0)	8 (6.4)	24 (19.2)	35 (28.0)	37.6	0.70

Note: Figures are numbers of innovations involving each element, with percentages of the district/city total in parentheses. Linkage density = number of non-government actor involvements (academia, business, community, and media) divided by the number of innovations. IT = information technology. Source: Interviews with Bappeda officials, July 2024.

Table 2 reveals a clear hierarchy of participation. Government was involved in all 125 innovations, reflecting the fact that regional innovation is initiated and registered by regional apparatus organisations. Among non-government actors, media was the most frequently involved (35 innovations; 28.0%), followed by community (24; 19.2%), academia (20; 16.0%), and business (8; 6.4%). This hierarchy is consistent across cases: media was the most frequent, or joint most frequent, non-government actor in every district/city, and business was the least frequent, or joint least frequent, in every case. Business was entirely absent from innovation in South Aceh and Aceh Jaya.

The hierarchy reflects the kind of contribution each actor makes. Media and community involvement represents communicative and participatory linkages: publicising innovations, socialising them to residents, and involving community groups in implementation—which require little resource commitment and can be mobilised by government on its own initiative. Academic involvement represents a knowledge linkage; it was occasional in most cases but concentrated in Banda Aceh City, which accounted for a quarter of all academic involvements (5 of 20) and where the province's main universities are located. Business involvement represents a resource linkage, requiring firms to commit funds, in-kind support, or delivery capacity, and it was the rarest of all.

This pattern inverts the logic of the classic helix models. In the Triple Helix, the core of innovation is the interaction among government, universities, and industry (Etzkowitz & Leydesdorff, 2000), while the media-based and culture-based public enters later as a further helix (Carayannis & Campbell,

2009). In the cases studied here, the helices added later—media and community—are the strongest, whereas the original partners of government—academia and, above all, business—are the weakest. Collaboration in regional innovation is thus government-centred and communication-oriented: the linkages that form most readily are those that publicise and legitimise innovation, not those that supply knowledge and resources. This is consistent with research on sparse regional environments, where firms and knowledge intermediaries are thin and collaboration has to be actively built (Salomaa et al., 2020), and with the collaborative governance argument that imbalances in resources and incentives shape which actors take part (Ansell & Gash, 2008).

Information technology, the enabling dimension, supported 47 innovations (37.6). Its use ranged from 28.3% of innovations in Aceh Jaya to all nine innovations in Banda Aceh City, the case with the densest actor linkages. Digitalisation was therefore most complete where collaboration was also strongest, although the small number of cases does not allow a causal relationship to be inferred.

Finally, no innovation met the complete Hexahelix configuration. Table 2 shows why this outcome is structurally constrained: because a complete configuration requires business participation, at most eight innovations could in principle have qualified, and none could have done so in South Aceh or Aceh Jaya. Informants confirmed that no innovation in their portfolios involved all five actors together. The business helix is therefore the critical missing linkage in regional innovation in these cases.

Monitoring and Evaluation of Regional Innovation Programs

In running innovation area through good management, there are 4 (four) elements or function management that can reflect the role of Bappeda in management innovation area namely: planning, organizing, directing, and controlling. Researchers Then using the indicators above For conclude How every district / city do management innovation areas that can influence improvement innovation area as well as sustainability of innovation programs the.

1. Planning

Form planning innovation areas carried out by Bappeda can seen from existence activity stages data collection and consultation as well as existence planning innovation concrete area. In this case planning implementation innovation area This, Bappeda does data collection and analysis moreover formerly with collecting innovation data area in the year previously as well as set activity innovation that will be done in the year walk.

Stages innovation data collection and consultation beginning carried out by Bappeda with request a number of OPDs for prepare innovation proposals area. The proposal contains a number of information innovation that will be implemented by each OPD, such as the name of the innovation, background behind innovation, goals benefit innovation, as well as budget implementation innovation. Elements other in see indicator planning is existence compilation concrete plan. Form concrete planning in innovation area can seen from There is or whether or not the System Roadmap Regional Innovation (SIDa) and regulations innovation area. Roadmap for strengthening SIDa This intended for determine direction and provide something context planning, approach term long, determine priority use source Power in frame increase Power competition area. Implementation innovation the area that aims For increase Power competition area This need planning term long through existence document strengthening SIDa.

Not yet available System Road Map Document Regional Innovation (SIDa) and Regulation Regional Innovation becomes example Not yet achievement element compilation concrete plans in planning innovation area this. Document important related planning and implementation innovation area This must arranged and coordinated its formation. Of all district / city that is carried out has have a derivative road map System Regional Innovation (SIDa).

2. Organizing

Organizing done aim for share Work to a few fields, set authority and coordination with field others to ensure achievement objective in A organization. Organizing in implementation innovation area This can seen from structure organization or institutional arrangements at Bappeda in frame increase innovation area. Tupoksi related implementation innovation area is in the field of Research, Regional Innovation, Program Control and Evaluation. In addition, one of the indicators in good organization according to Terry is existence specialization in A organization. As a Research and Development Agency regions, almost all Bappeda Already own Functional Researchers who have duties and functions related research and development at Bappeda. The existence of functional researchers assessed important for A organization government especially organization government that becomes a research and development agency functional area researchers is the driving force behind programs and activities at Bappeda.

3. Directing

Direction in increase innovation area This seen from How direction given by Bappeda to related OPDs implementation innovation area. As leading sector manager innovation region, Bappeda needs give direction to OPDs in give information related implementation innovation area. In terms of in general, Bappeda's direction to OPD-ODP has been done with well, where Bappeda has give information and directions in frame reporting innovation area. Giving socialization implementation innovation areas provided by Bappeda as form direction in implementation innovation area This done as form giving description about activities that will be done.

4. Supervision (*controlling*)

According to Terry (in Wijaya and Rifai, 2016: 47), there are three steps in measure good supervision. First, the activity measure deeds. The importance of supervision carried out government the area also shows one of the form activity measurements and actions carried out by Bappeda in implementation and management innovation area. There is a discussion together related implementation innovation area this also shows existence activity measure performance in implementation and management innovation areas in districts / cities.

Second, compare actions with established standards. Supervision as one of the good managements is needed existence established standards in A activities. Standards implementation innovation area This can determined by Bappeda together with other stakeholders related standards and planning implementation innovation area. In some district /city already own Standard Operational Innovation Procedure (SOP) area like West Aceh Regency, Southwest Aceh, Subulussalam, Aceh Jaya, and Banda Aceh.

Roles of the Hexahelix Elements in Regional Innovation

The aggregate pattern described above conceals differences in how each element contributes to regional innovation and in how its involvement varies across cases. This section examines each element in turn, using the distribution in Table 2.

Government

Government was involved in all 125 innovations (100%) in every district/city, as each innovation was initiated and registered by a regional apparatus organisation. Within government, the Bappeda acts as the main actor, coordinating the coaching, monitoring, and evaluation of regional innovation. Regional governments in all cases except South Aceh had issued derivative regulations on regional innovation, and West Aceh and Aceh Jaya encouraged all work units to take part in the regional innovation competition. Governments also allocated budgets for assessment teams, awards for innovation initiators, and, in some cases, additional funds for participating units. Because every involvement of a non-government actor took place within a government-initiated innovation, government functions not only as an innovator but also as the gatekeeper of collaboration: other actors enter regional innovation only when, and to the extent that, government agencies invite them. This corresponds to the convening and metagoverning role that the collaborative innovation literature assigns to public authorities (Sørensen & Torfing, 2011).

Academia

Academia was involved in 20 innovations (16.0%) and was present in all seven cases, but usually in only one to three innovations per case. Its share ranged from 55.6% in Banda Aceh City to 9.4% in Aceh Jaya. Academics contributed to the development of innovation products, provided coaching to initiators, and served on innovation assessment and evaluation teams; Aceh Jaya also involved academics in joint research with the National Research and Innovation Agency (BRIN). Even in Aceh Jaya, however, academic involvement reached fewer than one in ten innovations, which indicates that knowledge linkages tend to be project-based and selective rather than embedded across the innovation portfolio.

Business

Business was the least involved element, taking part in only 8 innovations (6.4%). It appeared in one or two innovations in five cases and was entirely absent in South Aceh and Aceh Jaya. Although companies operate corporate social responsibility (CSR) programmes for community empowerment that could support regional innovation, for instance through community-based enterprise or business incubation, this channel was rarely connected to the innovation agendas of regional governments. The weakness of the business helix is the main reason why no innovation reached the complete Hexahelix configuration.

Community

Community actors were involved in 24 innovations (19.2%) and were present in all cases. Their involvement took the form of community-based groups participating in empowerment programmes and in the implementation of innovations. The highest shares were found in Banda Aceh City (55.6%), South Aceh and Nagan Raya (28.6% each), and West Aceh (27.8%), whereas the lowest was in Aceh Jaya (7.5%). Community participation therefore did not increase with the number of innovations: the smaller portfolios were relatively more participatory than the largest one.

Media

Media was the most frequently involved non-government element, taking part in 35 innovations (28.0%) and appearing in every case; in Banda Aceh City it was involved in 8 of 9 innovations. Its role was mainly to publicise and promote innovations produced by regional governments and communities and to disseminate information about them to the wider public. This role is valuable for the visibility and legitimacy of innovation, but it is largely communicative and does not by itself add knowledge or resources to the innovation process.

Information Technology

Information technology, treated in this study as an enabling dimension rather than an actor, supported 47 innovations (37.6%). Its use ranged from 28.3% of innovations in Aceh Jaya and 28.6% in South Aceh and Nagan Raya to all nine innovations in Banda Aceh City. Application-based innovations expanded online public services, eased data collection and analysis for faster and better-targeted decisions, and supported transparency, accountability, and administrative efficiency. Digitalisation and collaboration, however, did not necessarily move together: Aceh Jaya had the largest number of application-based innovations in absolute terms (15) but the thinnest actor linkages, whereas Banda Aceh City combined full digitalisation with the densest

collaboration. This supports the treatment of information technology as an enabling infrastructure whose contribution depends on the actor linkages it serves, rather than as a substitute for them.

Analysis Findings Study Based on Innovation Theory

Analysis innovation in study This use perspective Mulgan and Albury (2003), argue that innovation sector public as changes that result in improvement mark for organization and community. Approach This Not only evaluate existence product new, but also changes in work processes, patterns services, policies and systems supportive collaboration sustainability innovation. Based on results research, implementation innovation can explain through five dimensions following:

1. Product Innovation

Product innovation product started from instrument or new media that previously Not yet available in organization public services in government and community. Research results show that organization develop application service as well as a functioning monitoring dashboard as means data integration, monitoring performance and delivery information to user's service. Presence innovation the change mechanism management previous information Still relies on manual processes to be more digital systems structured. More from just produce application new, innovation product give mark plus through improvement data accuracy, ease access information, and acceleration of the decision-making process decision. With Thus, the product innovations produced Not only functioning as device technology but also becoming instrument for increase governance effectiveness organization.

2. Innovation Process

Findings study shows that innovation No stop development product only, but also followed with change mechanism work in each organizational unit. Digitalization service push simplification procedure administration so that a number of stages previous service done manually can completed through system electronics. Changes the reduce duplication work, speed up the verification process, and increase ease of coordination work. Improvement of this process produce efficiency in use time, cost operational, and resources Power humans. In addition, more procedures simple create certainty service Because channel Work become clearer and easier understood by the community and apparatus. Condition the show that process innovation becomes factor important in increase quality organization service public.

3. Service Innovation

Innovation service looks from change method organization interact with community. Research finds that service No Again only done through face advance but also utilize digital platforms so public can access service without restricted space and time. On the other hand, the organization also applies approach service pick up the ball for reach group communities that have limitations access to service. Transformation the expand range service at a time increase responsiveness organization to need community. Service become easier accessed, time settlement shorter, and the costs incurred public become lower. With Thus, innovation service Not only increase efficiency organization, but also strengthens orientation service needs - centered public user.

4. Policy Innovation

Implementation innovation supported by policies that provide direction and certainty in implementation. Research results show existence regulations areas, such as Regulation the Regent and the innovation roadmap document, which became base organization innovation in the environment organization. Policy the Not only arrange mechanism implementation innovation, but also set targets, indicators success, as well as distribution role between work units. The existence of policy This show that innovation No is activities that are of a nature incidental but rather has integrated to in governance organization. Support regulations strengthen sustainability innovation Because provide runway law for allocation source power, development capacity apparatus, and evaluation program implementation.

5. System Innovation

Dimensions innovation system seen from development pattern Work collaborative involving various stakeholders' interests. Research finds the existence of a collaboration forum based hexahelix that brings together government, universities high, business world, community, media, and society in support development innovation. The partnership allows exchange knowledge, utilization source Power together, and strengthening capacity institutional. Collaboration cross sector also creates ecosystem more innovation adaptive to change environment strategic. Organization No Again Work in a way separate but rather build synergy for increase quality service public. Therefore that, innovation system becomes foundation important for sustainability innovation Because capable strengthen coordination, accountability, and effectiveness program implementation.

Based on results study show that applied innovation Not only utilization - oriented technology but also includes governance changes organization in a way comprehensive. Development applications and dashboards as innovation product followed by simplification of work processes, transformation pattern service, strengthening regulations, as well as formation system collaboration inter-stakeholder interests. Findings the indicates that success innovation sector public depends on integration various dimensions innovation. Innovation product will give optimal impact if supported by efficient work processes, responsive services, adaptive policies, and systems strong collaboration. With Thus, innovation No understood as implementation technology only, but as transformation capable organization increase effectiveness service public, strengthening capacity institutions, and create mark sustainable public.

CONCLUSION

This study set out to examine which Hexahelix actors take part in regional innovation in seven districts/cities of Aceh Province and why full Hexahelix collaboration does not emerge. The findings answer the first question clearly. Regional innovation is government-centred: government was involved in all 125 innovations, while non-government actors took part in a minority of them and in a consistent hierarchy—media (28.0%), community (19.2%), academia (16.0%), and business (6.4%). Collaboration is therefore real but thin and uneven, and it is dominated by communicative and participatory linkages rather than by the knowledge and resource linkages that lie at the core of helix models. No innovation met the complete Hexahelix configuration, and the absence of business is the principal

missing linkage: business was involved in only eight innovations and was entirely absent in two cases.

The study also shows that the Regional Innovation Index does not measure the depth of collaboration. Aceh Jaya, the only very innovative case, produced the largest number of innovations but had the thinnest actor linkages, whereas Banda Aceh City, with a small portfolio, was the most collaborative and the most digitalised. Information technology supported more than a third of all innovations, but digitalisation and collaboration did not necessarily move together. Regarding the second question, the evidence points to institutional conditions that keep collaboration within government: innovation is initiated and registered by individual agencies that act as gatekeepers for other actors, support from regional policy and budgets is uneven, and innovation initiators receive limited socialisation and technical guidance, so that some service improvements are never documented as innovations.

Conceptually, the study contributes by using the Hexahelix model as an analytical lens rather than a normative prescription. Distinguishing five collaborating actors from information technology as an enabling dimension makes it possible to identify which linkages are present and which are missing, and the Aceh cases reveal an inverted helix in which the actors added later to helix models are stronger than the original partners of government. This suggests that, in sparse regional environments, the analytical question is not how many actors a model includes but which relationships fail to form.

These findings have measured implications for regional innovation governance. The evidence does not support a general requirement that every region establish a Hexahelix forum: a forum that convenes all actors would add little where the missing relationships are specific. A more targeted approach would focus on the weakest linkages—connecting firms' CSR and partnership programmes to regional innovation agendas through MoUs or MoAs, and turning ad hoc academic involvement into more systematic knowledge partnerships—with the Bappeda acting as broker. The Index assessment could also give greater weight to the quality and depth of collaboration, rather than mainly to the number of registered innovations. Formal multi-actor forums may then be useful where such bilateral linkages already exist and need coordination.

This study has limitations. Actor involvement was recorded per element rather than per innovation, so the exact combinations of actors within individual innovations could not be observed; the data refer to a single assessment period; and Banda Aceh City was analysed without city-level informants. Future research could trace actor combinations at the level of individual innovations, follow cases over several Index periods, and examine the business helix in more depth to explain why firms remain outside regional innovation.

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Authorship Contributions

Mukhlizar, Dar Kasih, and Bachrum Syahputra contributed to the research and the drafting of the manuscript. All authors have reviewed and approved the final manuscript. Mukhlizar serves as

the corresponding author and is responsible for all communication with the journal.

Conflict of Interest

The authors declare that they have no financial or personal interests that could have influenced the research results reported in this article.

Ethics Statement

This research utilizes qualitative data obtained from individuals involved in governance, specifically regarding regional innovation and policy processes. The identities of the participants have been kept confidential; sensitive personal information has not been disclosed, and the data are used solely for academic purposes. No formal ethics approval number is provided, as no such documentation exists within the research records.

Data Availability

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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